



---

## Fall 2023

---

<b>Course Number</b>	ARCH 680	<b>Classroom</b>	TBC
<b>Course Name</b>	From Waste to Artifact		
<b>Pre/Co-Requisites</b>	N/A		
<b>Instructor</b>	Alexander Crosby	<b>Office Hours/Location</b>	By appointment only
	<b>Email:</b> <a href="mailto:Alexander.crosby@ucalgary.ca">Alexander.crosby@ucalgary.ca</a>		
<b>Class Dates</b>	Tuesday, 6:30 – 8:00pm, In-person, TBC  Thursday, 6:30 – 8:00pm, In-person, TBC		
<b>Instructor Email Policy</b>	Please note that all course communications must occur through either the classes MS Teams channel or through @ucalgary emails. Instructor will respond to student emails and discord posts within 48 hours.		

### Course Description:

**Calendar Description:** This course investigates the circular potential of waste through formulating, testing, and validating waste-based 3d printable material composites. Through practical projects, students will consider how additive manufacturing and generative design pipelines can be utilized in the translation of waste into meaningful architectural artifacts. Learning objectives will center around bio-composite formulation, visual scripting, material testing, and analysis competencies.

**Link to Calendar Description:** <https://www.ucalgary.ca/pubs/calendar/current/architectural-studies.html#38564>)

**Additional Description:** This course investigates the circular potential of waste through surveying, testing, and validating 3d-printable waste-based material composites. From single-use cups from our daily coffees to sawdust created from the production of furnishings for our homes, waste is produced in some shape or form. Often discarded, these materials could play new roles in our daily experiences and spatial structures. As such, recent research into waste-based biomaterials has developed knowledge around processing and translating waste into new bio-composites, bioplastics, and bio-cementitious materials. Additionally, additive manufacturing (AM) methods like liquid deposition modeling (LDM) present new avenues for fabricating with bio-composite materials. Waste-based materials and AM processes can also be paired with digital analysis and desktop testing procedures to characterize and validate material performance. The overall goal of this elective is to evaluate the use of waste-based material composites, physically and digitally, in architectural artifacts and building components. Focusing on practical assignments, this course will provide foundations around material composite development, parametric tool-pathing, bench testing, and analysis. In groups, students will design, formulate, and assess 3d-printable waste-based material composites via desktop mechanical testing and digital analysis. Course progression will involve students iteratively assessing and evaluating feedback received from their materials, digital frameworks, and mechanical tools utilized throughout the course. The elective will culminate in a suite of computationally generated geometry, 3d printed test specimens, and a final digital and/or physical artifact validated by the material testing and digital analysis.

**Key Words:** Bio-composites, Waste, Feedback-loops, Material Testing, Material Driven Design, Additive Manufacturing,

**Course Hours:** 3 units; (1.5 Lecture +1 .5 Workshop/Tutorial)

## Course Format

This course emphasizes hands-on physical and digital experiences completed through assignments. The course will additionally provide supplementary lectures, demonstrations, workshops, and learning resources to prepare students for hands-on experiences. In balancing time between your various courses and other commitments, you should allot approximately 9 hours per week outside of class time for this course, budgeted roughly as follows:

<i>Course Component</i>	<i>Time Breakdown (hours)</i>	<i>Time Breakdown (%)</i>
Weekly Lectures, Workshops, Tutorials, and Review Session	3.0	25.0

Studies/ Experiments	7.5	62.5
Logbook Entries	1.5	12.5

You will be responsible for managing your own time. The weekly time allocations will vary depending on course deadlines.

## Course Learning Outcomes

Besides the accumulation of factual knowledge, the primary learning objectives of this course are practical skills centered around additive manufacturing, computational design, and materials and methods. You should develop the ability and competencies around the following:

1. *Develop literacy around technological ideas, skills, concepts, and terminology.*
  - a. Take in and digest concepts and terminology through readings, lectures, demonstrations, and review sessions,
  - b. Develop an understanding of 3d-printing and composite formulation concepts, materials, and methods,
  - c. Synthesize and apply concepts and terminology through discussion, diagramming, sketching, and project work,
  - d. Document and catalog in term logbook.
  
2. *Explore material properties, attributes, and characteristics in relation to waste-based material composite formulation.*
  - a. Develop and apply an understanding of extrinsic and intrinsic material properties,
  - b. Consider the contextual impacts that physical environments have on materials,
  - c. Hypothesize material-environment relationships in material development and design work,
  - d. Develop an understanding of material composite formulation and processing practices,
  - e. Consider a variety of binders, particulates, colorants, aggregates, and material wastes that can make up composite materials.

3. *Create custom digital fabrication tools that aid in the generation, analysis, and fabrication of material artifacts.*
  - a. Generate iterative and performance-driven testing options that tie into physical and digital testing methods,
  - b. Translate geometry into toolpaths and gCode for fabrication via visual scripting or other market-available slicing software,
  - c. Develop digital tools to assist in the display and assessment of key fabrication metrics,
  - d. Write and/or draw diagrammatic analytical and critical assessments of documented design work.
  
4. *Conduct small-scale physical and digital material tests and analysis.*
  - a. Develop hands-on testing methods for material composites and 3D-printed test specimens,
  - b. Develop digital tools and reality capture processes that effectively analyze material & environmental phenomena,
  - c. Pull key ideas from parametric material testing tools used in class demonstrations,
  - d. Rationalize and balance empirical findings against design requirements and needs.
  
5. *Conduct technological analysis and exploration in the context of design.*
  - a. Develop technology tools to move forward with project work,
  - b. Generate a variety of analytical options and responses to project requirements,
  - c. Think through, speculate, and rationalize case-use for project work,
  - d. Express technology ideas in cogent and articulate diagrams, test samples, and drawings,
  - e. Document and catalog in term logbook.

## Learning Resources

### Required readings, textbooks and learning materials:

There are no required readings, textbooks and/or learning materials. The instructor will provide a curated set of optional readings and links to appropriate learning resources throughout the term. These resources will be posted to the D2L site and the MS Teams Channel.

### **Required Hardware:**

- Access to a PC that can run Rhino 7/ Grasshopper
  - Please note: Macs can be used for majority of course work but may present issues with PC Only plugins used within the course.
  - Refer to the following link for system requirements:  
<https://www.rhino3d.com/7/system-requirements/>
- Computer Mouse with center wheel (required)
- SD Card Reader (required)

### **Required Software:**

- Access to Adobe InDesign 2019 and above
- Access to Rhino 7/ Grasshopper
  - Students should be able to access a 90-day trial version for Rhino 7/Grasshopper. Alternatively, students can elect to purchase a perpetual student license for \$195 US.
  - Students can access student licenses here:  
<https://www.rhino3d.com/en/sales/north-america/Canada/>
  - Students can download an evaluation trail here:  
<https://www.rhino3d.com/download/rhino-for-windows/evaluation>
- Bifocals (Grasshopper Plugin) - Free
  - Students can access Bifocals here:  
<https://www.food4rhino.com/en/app/bifocals>
- Access to 3d-Scanning and/or Photogrammetry software.
  - Autodesk Recap: Students can access free student licenses for Autodesk Recap here: <https://www.autodesk.com/education/edu-software/overview?sorting=featured&filters=individual>
  - Meshroom: Students can access opensource software here:  
<https://github.com/alicevision/Meshroom>
- Notepad (PC) or TextEdit (Mac) - Free
  - Default text editors which should come with operating systems.

## **Workshop Safety Training Requirement**

If a course requires the use of the SAPL workshop, students must complete all online University of Calgary safety courses, the online Trajectory safety training course, as well as in-person workshop training and a grade of pass on the final evaluation project, to be granted access to the SAPL workshop. This training is offered once a year, around the start of the Fall term and has a completion deadline.

## **Additional Classroom Conduct and Related Information**

### **Tutorial, Workshop and Discussion Participation:**

While there is no mark attributed to participation in tutorials, workshops and class discussions, success in the course will be dependent on participation and engagement in these events.

### **Microsoft Teams Use and Conduct:**

Microsoft Teams will be utilized as a platform for information sharing and for inquires specific to the course, its assignments and associated content. Students must behave in a professional manner on this platform. Students, employees, and academic staff are also expected to demonstrate behaviour in class that promotes and maintains a positive and productive learning environment. Harassment of any kind will not be tolerated.

### **Guidelines for Zoom Sessions in Online Classes:**

Students are expected to participate actively in all Zoom sessions and to turn on their webcam. Please join our class in a quiet space that will allow you to be fully present and engaged in the Zoom sessions. Students must behave in a professional manner during the session. Students, employees, and academic staff are also expected to demonstrate behaviour in class that promotes and maintains a positive and productive learning environment.

### **Assessment Components:**

Students will be looking at transforming waste material into architectural artifacts via bio-composite slurry development and additive manufacturing pipelines. To do so will require the uptake and synthesis of key terminology, ideas, and concepts surrounding materials, computation, and additive manufacturing. The development of this work will be recorded and presented in a term logbook, which students will develop over the course of the term. The logbook should be a curated document that illustrates research, bench testing, digital analysis, physical and digital studies, and speculations, as well as provide written observations, findings, and analysis of work. Students should include a variety of captioned images, stills, drawings, 3D scans, and/or diagrams as a means of illustrating their project development. The term logbook will not only be a tool to record project development but will also act as a presentation tool, which students will use to present work at three of the four major project milestones throughout the term:

## **Logbook Entry I: Palette Study | Individual | 20%**

**Description:** In this assignment, students will individually survey, research, and test potential material feedstocks for use in 3d-printable slurries. Students can choose to focus on various fibers, aggregates, binders, and additives. Students are expected to look to their environments, source potential waste materials, and supplement initial explorations with materials from provided material kits. Students are expected to perform simple bench tests on potential base materials and/or recipes. Additionally, students are expected to perform basic digital analysis on early tests – outcomes of these assessments are intended to inform recipe ingredients and proportions. Findings will be used to formulate a proposed material palette comprising fibers, aggregates, binders, and additives that can be taken into the next part of the term.

**Objective:** To develop a base understanding of LDM slurry formulation and home in on potential directions and avenues for the following assignments.

**Aligned Course Learning Outcomes:** 1, 2 & 3

## **Logbook Entry II: Soft Body Studies | Group | 30%**

**Description:** In this assignment, student groups will work to iteratively develop initial 3d-printable slurries and geometric scripts for 3d printing. As groups work through their slurry and script development, they will subject their work to simple bench-testing studies that test both physical and digital attributes of slurries. Students are expected to document and record these studies as well as present observations, analysis, and findings discovered while working through the work. Lastly, students will be expected to present findings and speculate on case use.

**Objective:** Formulate, test, and validate initial 3d-printable waste-based slurries & the development of initial toolpath and print metrics generator.

**Aligned Course Learning Outcomes:** 1, 2, 3, 4 & 5

## **Logbook Entry III: Artifact Studies | Group | 40%**

**Description:** In this assignment, students will work to develop and validate their material artifacts. Before this assignment, students explored slurry development, material processes, bench-testing methods, tailored geometry, simulation, and analysis. The name of the game now is to bring all this knowledge together to create a final material artifact(s). Students are expected to iteratively develop their artifacts using feedback from previous and new studies. Artifacts should be architectural elements or proto-architectural forms; regardless, the artifact should be informed by specific material, digital, and physical feedback loops. Students are expected to document and record these studies and present observations, analyses, and findings.

**Objective:** To refine waste-based slurries and production procedures while iteratively developing and translating waste-based slurries into a proof-of-concept material artifact.

**Aligned Course Learning Outcomes:** 1, 2, 3, 4 & 5

### **Final Exhibition | Group | 10%**

**Description:** In this assignment, students will work to present findings, samples, and material artifacts in a final exhibition. Students are expected to save material specimen, material tests, 3D-scans, geometry, toolpaths, and artifacts produced throughout the semester for display in exhibition. Additionally, using provided templates, students are expected to produce a series of presentation boards that outline their material research, material palettes, digital analysis, bench testing, and material artifacts. Students are not expected to produce new work for the exhibition but instead are expected to pull and curate documentation from their logbooks to use for their boards. The instructor will be responsible for the overall curation and setup of the exhibition.

**Objective:** To showcase course content, outcomes, and findings to SAPL faculty, students, staff, and members of the public.

**Aligned Course Learning Outcomes:** 1 & 5

While much of the term requires group work and a portion of each entry will be assessed on the cohesiveness of a group's project development, logbook entries will be assessed on an individual basis. During group presentations, portions of individual logbooks from group members can either be compiled or sequenced for group presentations. The presentations will make up 30% of the total milestone weight, while individual contributions will make up the remaining 70% of the total milestone. Where group work is used within the logbook, please make sure to identify individual and group contributions. In cases where there is group conflict, group members can fill out, complete, and submit a peer-evaluation form at any time throughout the semester. This is meant to safeguard student contributions to assignments in the face of group conflict. It will be the instructor's responsibility to follow up with the group, and it will be up to the instructor's discretion on how evaluations will be re-adjusted based on the peer evaluation forms and inquiry.

\*Please note that a logbook InDesign template will be provided. It is recommended that students utilize this template so that the graphic layout and presentation of work is simplified.



# Assessment and Evaluation Information

**Attendance and Participation Expectations:** Students are expected to come to class and present in-progress and final work. Only final work will be assessed in-class. Additionally, while there are no other attendance requirements per se, it is important that students come to class prepared to engage in class lectures, discussions, workshops, tutorials, and presentations.

**Guidelines for Submitting Assignments:** As a rule, work will be presented in-class as well as submitted to D2L prior to in-class presentations.

**Feedback:** Written feedback will be brief; students are encouraged to seek oral elaboration. Feedback for logbook assignments will be provided in-class. Additional written feedback will be provided when assessment for work is posted. Please refer to term schedule for dates of deadlines.

**Team and individual work:** Architectural practice is collaborative, so in preparation for that you'll be doing a fair amount of work in teams of 2 or 3. Care is taken to make the teamwork agreeable and productive, e.g. students help make the teams as equitable as possible. Evident fairness between teams enables us to keep teams consistent, and this gives time for effective group patterns to develop.

**Collective Workshop Management:** It will be the student's responsibility to ensure that collective workspaces are cleaned, maintained, and kept in safe working conditions. Students will specifically be responsible for the following:

- Ensure equipment and tools are cleaned up after use.
- Ensure materials and consumables are cleaned up after use.
- Ensure workspace is wet mopped and kept dust free.
- Ensure workspace is kept free of tripping hazards.
- Report unsafe conditions to instructor.

***If a student or student group fails to uphold a clean and safe work environment for the rest of the class and faculty, they will be subject to a deduction of up to 10% per assignment.*** It will be the instructor's responsibility to ensure that students have access to equipment and consumables for maintaining the space. The instructor will do their best to assist with the cleaning and maintenance of the shared workspace.

**Final Examinations:** There will be no final examinations outside for this class. All course component work will be presented during class time.

**Expectations for Writing** (<https://www.ucalgary.ca/pubs/calendar/current/e-2.html>):

**Late Assignments:** Deductions for late submissions encourage time management and maintain fairness among students. Late assignments will be deducted 1/3<sup>rd</sup> of a letter grade per day late. With a medical note submitted to the school office, a course assignment (including a final assignment) may be submitted more than three weekdays late without penalty. The number of weekdays depends on how long the student is unable to work, as indicated in the medical note. If more than one course is affected, students should consult with the instructor to set a new schedule of due dates for course.

**Criteria that must be met to pass:** Students must attain a passing grade on all log-book components in order to meet the course requirements. Students should reach out and discuss missing coursework or course components with the instructor in a timely manner.

## Grading Scale:

Grade	Grade Point Value	4-Point Range	Percent	Description
A+	4.00	4.00	95-100	Outstanding - evaluated by instructor
A	4.00	3.85-4.00	90-94.99	Excellent - superior performance showing comprehensive understanding of the subject matter
A-	3.70	3.50-3.84	85-89.99	Very good performance
B+	3.30	3.15-3.49	80-84.99	Good performance
B	3.00	2.85-3.14	75-79.99	Satisfactory performance
B-	2.70	2.50-2.84	70-74.99	Minimum pass for students in the Faculty of Graduate Studies
C+	2.30	2.15-2.49	65-69.99	All final grades below B- are indicative of failure at the graduate level and cannot be counted toward Faculty of Graduate Studies course requirements.
C	2.00	1.85-2.14	60-64.99	
C-	1.70	1.50-1.84	55-59.99	
D+	1.30	1.15-1.49	50-54.99	
D	1.00	0.50-1.14	45-49.99	
F	0.00	0-0.49	0-44.99	

A student who receives a "C+" or lower in any one course will be required to withdraw regardless of their grade point average (GPA) unless the program recommends otherwise. If the program permits the student to retake a failed course, the second grade will replace the initial grade in the calculation of the GPA, and both grades will appear on the transcript

The School of Architecture, Planning and Landscape will not permit the Flexible Grade Option (CG Grade) for any course offered by the School.

<https://www.ucalgary.ca/pubs/calendar/current/f-1-3.html>

# CACB Student Performance Criteria

The following CACB Student Performance Criteria will be covered in this course at a primary level (other criteria will be covered at a secondary level): C2: Materials

<b>Topic Areas &amp; Detailed Class Schedule</b>				
	<b>Course Schedule Date</b>	<b>Tuesday Topic</b>	<b>Thursday Topic</b>	<b>Assignments/ Due Dates</b>
<b>P A R T 1</b>	Sept 05 – 08	Lecture: Course Introduction + Materials and Methods I	Workshop: Materials I (Mixing Intro) + Grasshopper Introduction	Logbook I: Introduced  Final Exhibition: Introduced
	Sept 11 – 15	Workshop: Materials II (Bench Testing)	Workshop: Scripting I (Scanning + Scripting)	
	Sept 18 – 22	General Tutorials	Logbook I: Presentations	Logbook I: Due start of Thursday's class.  Logbook II: Introduced
<b>P A R T 2</b>	Sept 25 – 29	Lecture: Materials and Methods II	Workshop: Scripting II (Test Geometry Intro)	Final Exhibition: Reminder
	Oct 02 - 06	Workshop: Materials III (Printing Intro)	Workshop: Scripting III (Test Geometry Development)	
	Oct 09 -13	Workshop: Materials IV (Slurry Trouble Shooting)	Logbook II: Group Review	

	Oct 16 - 20	General Tutorials	Logbook II: In-class Presentations	Logbook II: Due start of Thursday's class.  Logbook III: Introduced	
P A R T  3	Oct 23 -27	Lecture: Materials + Methods III	Workshop: Scripting IV (Geometry Development)	Final Exhibition: Reminder	
	Oct 30 –Nov 03	Workshop: Materials V (Drying + Atmospheres)	Logbook III: Group Crits	Final Exhibition: Templates introduced	
	Nov 06 - 10	<i>Block Week – No Class</i>			
	Nov 11 - 17	<i>Term Break – No Class</i>			
	Nov 20 - 24	Workshop: Scripting V (Geometry Development)	Workshop: Materials VI (Printer Trouble Shooting)		
	Nov 27 – Dec 01	Logbook III: Penultimate Review	Final Exhibition: Working Period		
	Dec 04 – 06	Logbook III: In class Presentation  Course Wrap-up/ Roundtable	<i>No Class</i>	Logbook III: Due start of Tuesday's class	
P A R T  4	Dec 11 - 15	<i>Final Reviews/ Exhibits/ Submissions No class</i>  <i>Exhibition Reception (TBD)</i>		Final Exhibition: Materials to be submitted end of day December 6 <sup>th</sup> .  <b>Final Exhibition</b>	

## Special Budgetary Requirements

### **Materials and Consumables:**

Students will be required to source materials and consumables for this course. The instructor will make the best efforts to keep costs down where possible. Students should expect to pay +/- \$75.00 CAD for binders, aggregates and mixing consumables. Cost sharing in group scenarios and salvaging materials should reduce student costs and are recommended. Material lists and/or access to base recipe lists will be provided so an appropriate amount of materials can be sourced for student projects.

### **Personal protective equipment (PPE):**

Safety Glasses, N-95 particulate masks and vinyl/latex gloves may be required for mixing materials. Students will be required to purchase PPE, but the instructor will make best efforts to reduce costs around PPE. It is recommended that students cost share to keep costs down.

## University of Calgary Policies and Supports

### **ACADEMIC ACCOMMODATION**

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: <https://www.ucalgary.ca/legal-services/university-policies-procedures/student-accommodation-policy>

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities: <https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Accommodation-for-Students-with-Disabilities-Procedure.pdf>. Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, preferably in writing, to their instructor (contact information on first page above).

SAS will process the request and issue letters of accommodation to instructors. For additional information on support services and accommodations for students with disabilities, visit [www.ucalgary.ca/access/](http://www.ucalgary.ca/access/).

## **ACADEMIC MISCONDUCT**

Academic Misconduct refers to student behavior which compromises proper assessment of a student's academic activities and includes: cheating; fabrication; falsification; plagiarism; unauthorized assistance; failure to comply with an instructor's expectations regarding conduct required of students completing academic assessments in their courses; and failure to comply with exam regulations applied by the Registrar.

For information on the Student Academic Misconduct Policy and Procedure please visit:  
<https://www.ucalgary.ca/legal-services/university-policies-procedures/student-academic-misconduct-policy>

Additional information is available on the Academic Integrity Website at <https://ucalgary.ca/student-services/student-success/learning/academic-integrity>.

## **COPYRIGHT LEGISLATION:**

All students are required to read the University of Calgary policy on Acceptable Use of Material Protected by Copyright (<https://www.ucalgary.ca/legal-services/university-policies-procedures/acceptable-use-material-protected-copyright-policy>) and requirements of the copyright act (<https://laws-lois.justice.gc.ca/eng/acts/C-42/index.html>) to ensure they are aware of the consequences of unauthorised sharing of course materials (including instructor notes, electronic versions of textbooks etc.). Students who use material protected by copyright in violation of this policy may be disciplined under the Non-Academic Misconduct Policy (<https://www.ucalgary.ca/pubs/calendar/current/k.html>).

## **INSTRUCTOR INTELLECTUAL PROPERTY**

Course materials created by instructors (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the instructor. These materials may NOT be reproduced, redistributed or copied without the explicit consent of the instructor. The posting of course materials to third party websites such as note-sharing sites without permission is prohibited. Sharing of extracts of these course materials with other students enrolled in the course at the same time may be allowed under fair dealing.

## **FREEDOM OF INFORMATION AND PROTECTION OF PRIVACY**

Student information will be collected in accordance with typical (or usual) classroom practice. Students' assignments will be accessible only by the authorized course faculty. Private information related to the individual student is treated with the utmost regard by the faculty at the University of Calgary.

## **SEXUAL AND GENDER-BASED VIOLENCE POLICY**

The University recognizes that all members of the University Community should be able to learn, work, teach and live in an environment where they are free from harassment, discrimination, and violence. The University of Calgary's sexual violence policy guides us in how we respond to incidents of sexual violence, including supports available to those who have experienced or witnessed sexual violence, or those who are alleged to have committed sexual violence. It provides clear response procedures and timelines, defines complex concepts, and addresses incidents that occur off-campus in certain circumstances. Please see the policy available at <https://www.ucalgary.ca/legal-services/university-policies-procedures/sexual-and-gender-based-violence-policy> .

## **UNIVERSITY STUDENT APPEALS OFFICE**

If a student has a concern about a grade that they have received, they should refer to Section I of the Undergraduate Calendar (<https://www.ucalgary.ca/pubs/calendar/current/i-3.html>) which describes how to have a grade reappraised. In addition, the student should refer to the SAPL's Procedure for reappraisal of grades

## **OTHER IMPORTANT INFORMATION**

Please visit the Registrar's website at: <https://www.ucalgary.ca/registrar/registration/course-outlines> for additional important information on the following:

- Wellness and Mental Health Resources
- Student Success
- Student Ombuds Office
- Student Union (SU) Information
- Graduate Students' Association (GSA) Information
- Emergency Evacuation/Assembly Points
- Safewalk